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To cite this version:
Kostiantyn Maksymenko, Maureen Clerc, Théodore Papadopoulo. Data-driven cortical clustering to provide a family of plausible solutions to the M/EEG inverse problem. BIOMAG 2018, Aug 2018, Philadelphia, United States. hal-01874281
Data-driven cortical clustering to provide a family of plausible solutions to the M/EEG inverse problem

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1 MOTIVATION
- Sources are represented as a connected cortical region, rather than a dipole
- Several separated cortical regions can fit the data with similar accuracy. While convex optimization based methods give a single solution, we explore a family of plausible solutions
- Estimate not only the position, but also extension range of the regions

2 ASSUMPTIONS
- Data model: \( y = Lx + N \) (\( L \) is a lead field)
- Source space: cortical mesh
- Brain activity \( \mathcal{X} \): single region with a constant amplitude over this region; one time sample

3 METHOD
Adapting hierarchical clustering algorithm [1] to fit M/EEG data:
- Mesh vertices represent initial clusters
  Mesh edges define the cluster neighborhood
- Among all inter neighbors clusters, find clusters \( C_i^*, C_j^* \) which minimize:
  \[
  E(i, j) = \min_a \| y - a \cdot (L(c_i) + L(c_j)) \|_2 + R(i, j)
  \]
- Merge these clusters: \( c_k = c_i^* \cup c_j^* \), \( L(c_k) = L(c_i^*) + L(c_j^*) \)
- Repeat until the whole cortex is one cluster
- Cut the tree to obtain separated “growing” regions
- Select best regions by thresholding data fitting error

4 RESULTS
- Simulated MEG signal of one active region (in blue) with additive noise
- Reconstructed with and without regularization.
  (we regularized region shapes but other alternatives are possible)
- Obtained 3 spatially separated regions which explain the data with high accuracy (with regul.)
- Estimated the extension range of each region

5 CONCLUSIONS
New approach for the M/EEG inverse problem which:
- Deals with a “growing region” object, which allows to explore space of solutions
- Gives several candidates for solution and their extension ranges

Future work:
- Regularization term to be investigated
- Error thresholding to be investigated
- Multiple source case by adapting the MUSIC method [2]

Acknowledgement: This work has received funding from the European Research Council (ERC) under the European Union’s Horizon 2020 research and innovation program (ERC Advanced Grant agreement No 694665: CoBCoM - Computational Brain Connectivity Mapping).

References: